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# Managing Nitrogen in Almond Orchards

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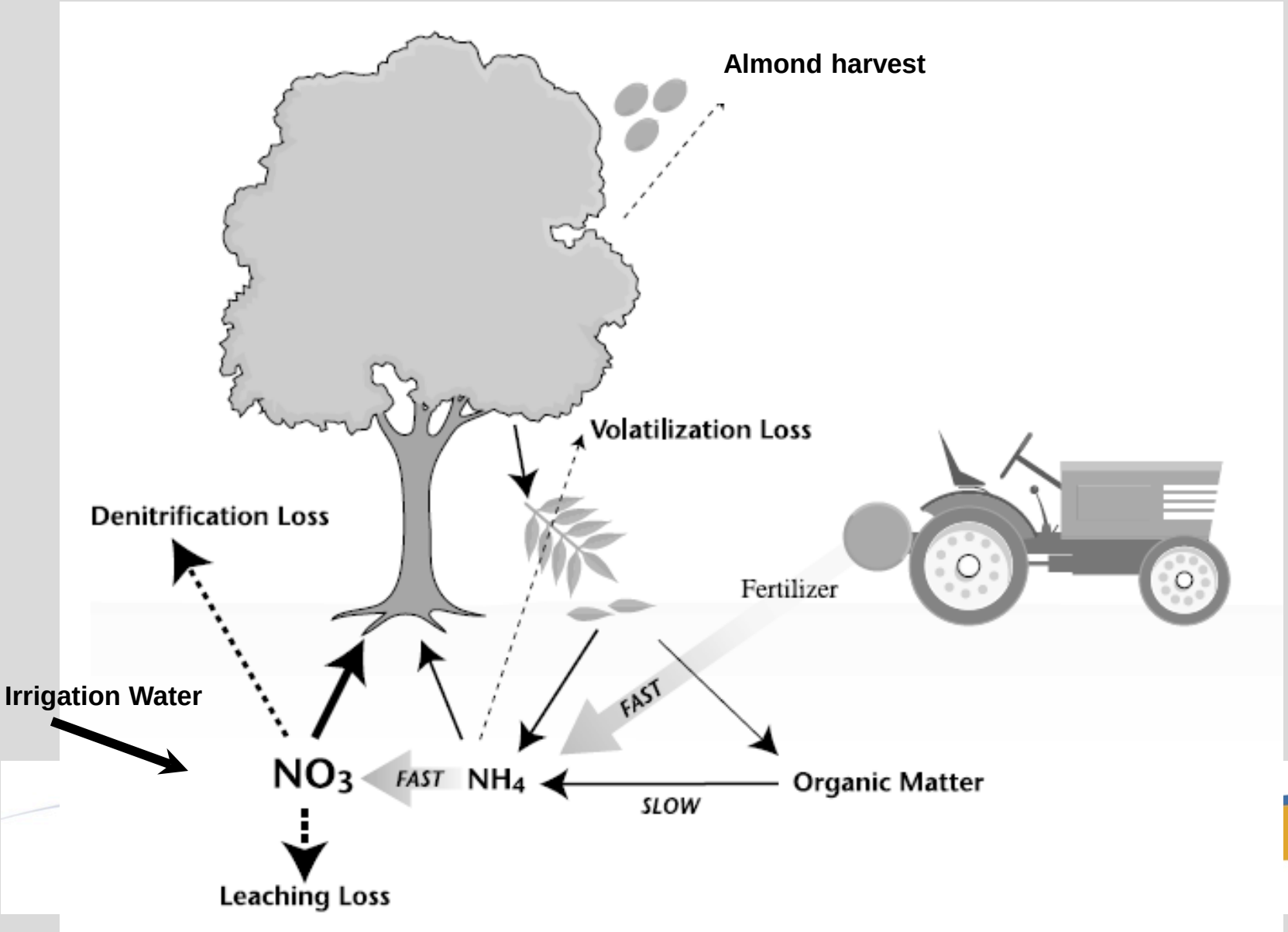
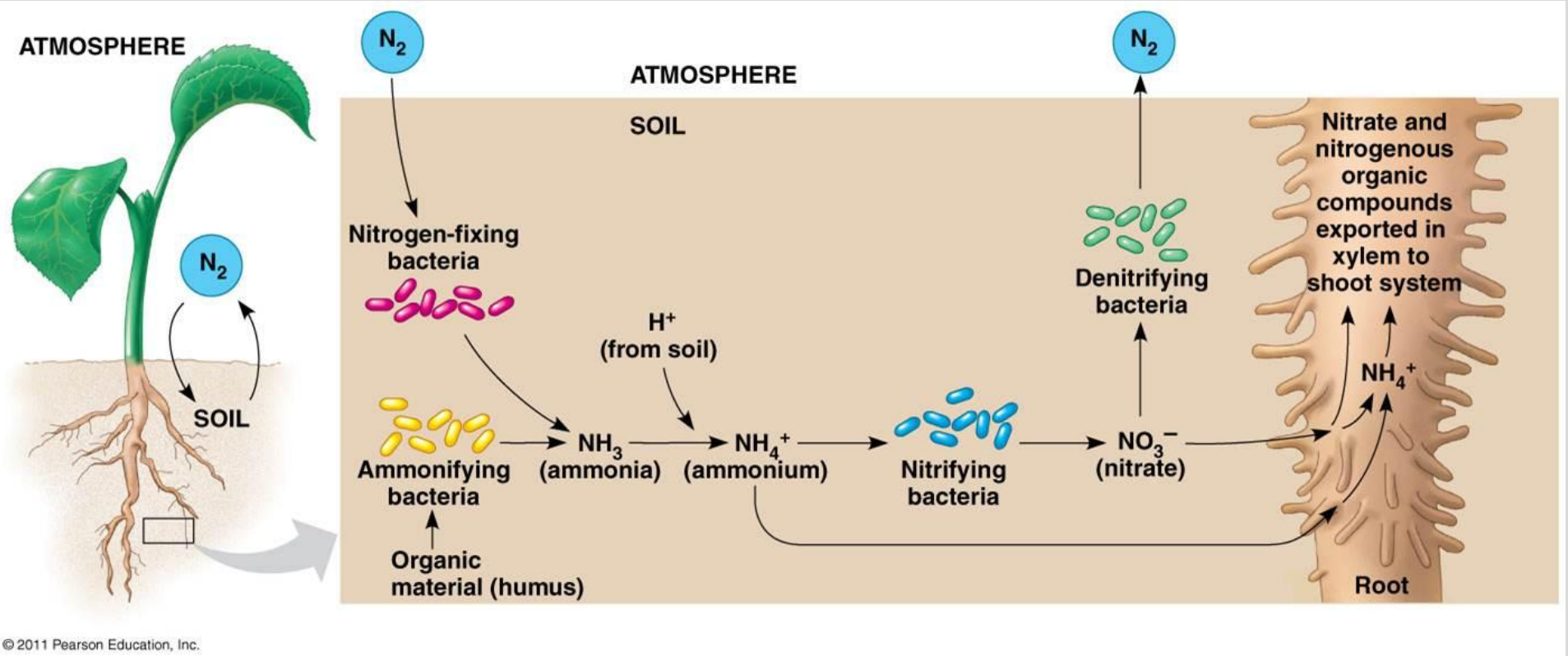
# Managing Nitrogen in Almond Orchards

- Nitrogen cycle, tree physiology
- Sources of nitrogen
- Nitrogen demand of almond
- Nitrogen rates for maximal almond production
- Nitrogen and hull rot
- Nitrogen needs of developing orchards

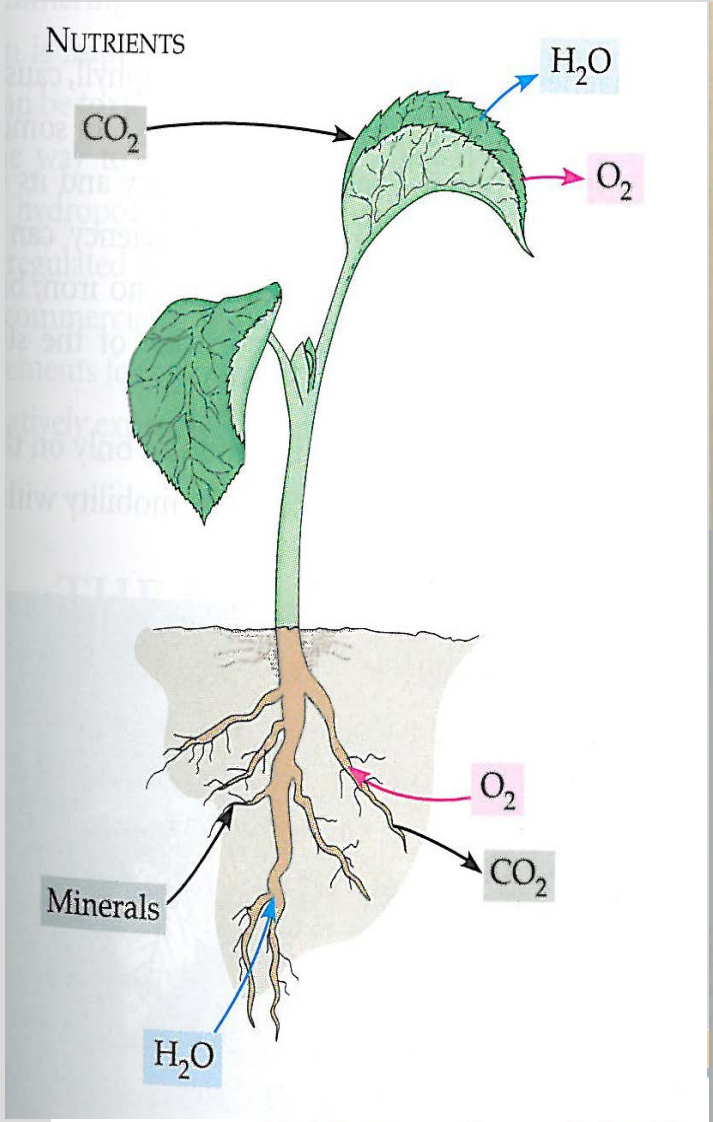
# Nitrogen Cycle within Orchard

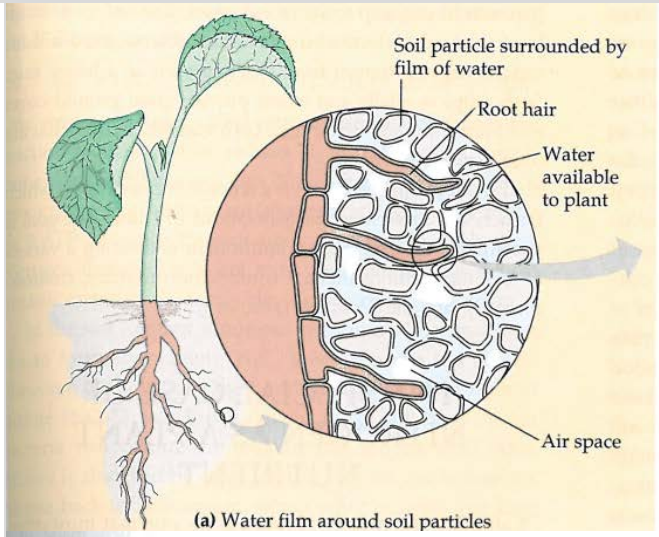


# Nitrogen Cycle within Orchard

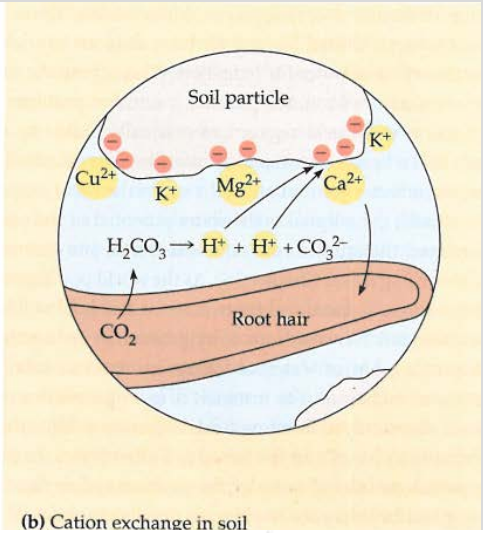


# N/Mineral Movement w/in Plants

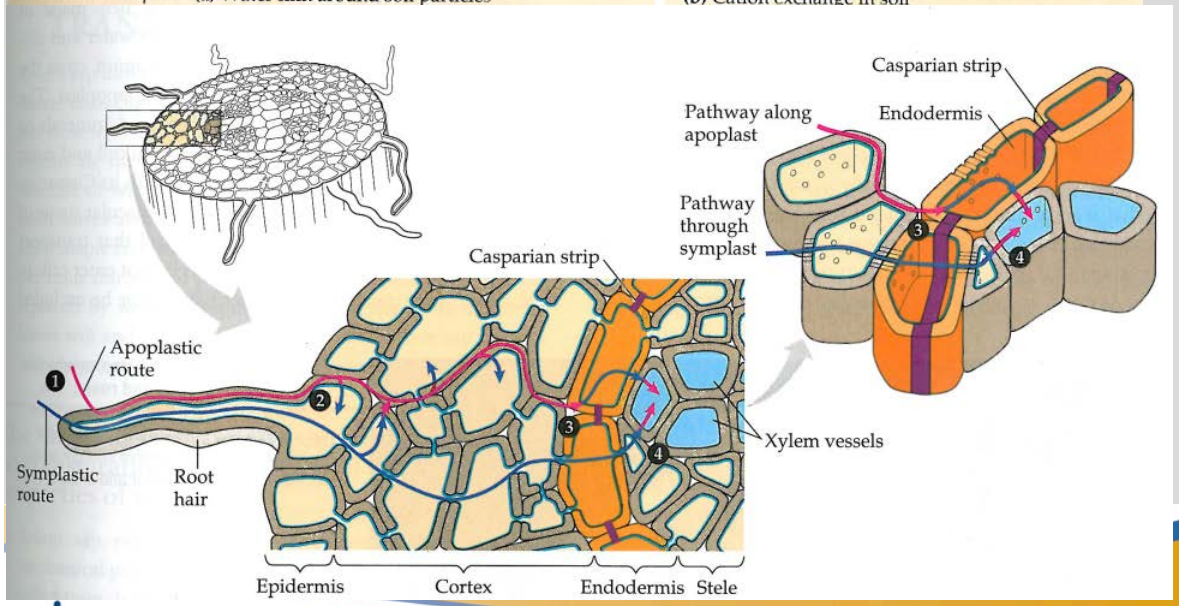



(a) Water film around soil particles




(b) Cation exchange in soil



# Nitrogen Sources:

- **Inorganic N fertilizers:**
  - **Urea**
  - **Ammonium ($NH_4^+$)**
  - **Nitrate ($NO_3^-$)**
- **Blends:**
  - Urea Ammonium Nitrate (UN-32) – liquid blend
  - Calcium Ammonium Nitrate (CAN-17) – liquid blend
- **Groundwater**
- **Manures/Compost**
- **Other sources:** Fulvic/Humic Acids, Compost teas

# Efficient Nitrogen Management
## *-the 4 R's-*

- Apply the Right Rate
  - Match supply with tree demand (all inputs- fertilizer, organic N, water, soil).
- Apply at the Right Time
  - Apply coincident with tree demand and root uptake.
- Apply in the Right Place
  - Ensure delivery to the active roots.
  - Minimize movement below root zone
- Using the Right Source and Monitoring
  - Maximize uptake, maximize response and minimize loss.

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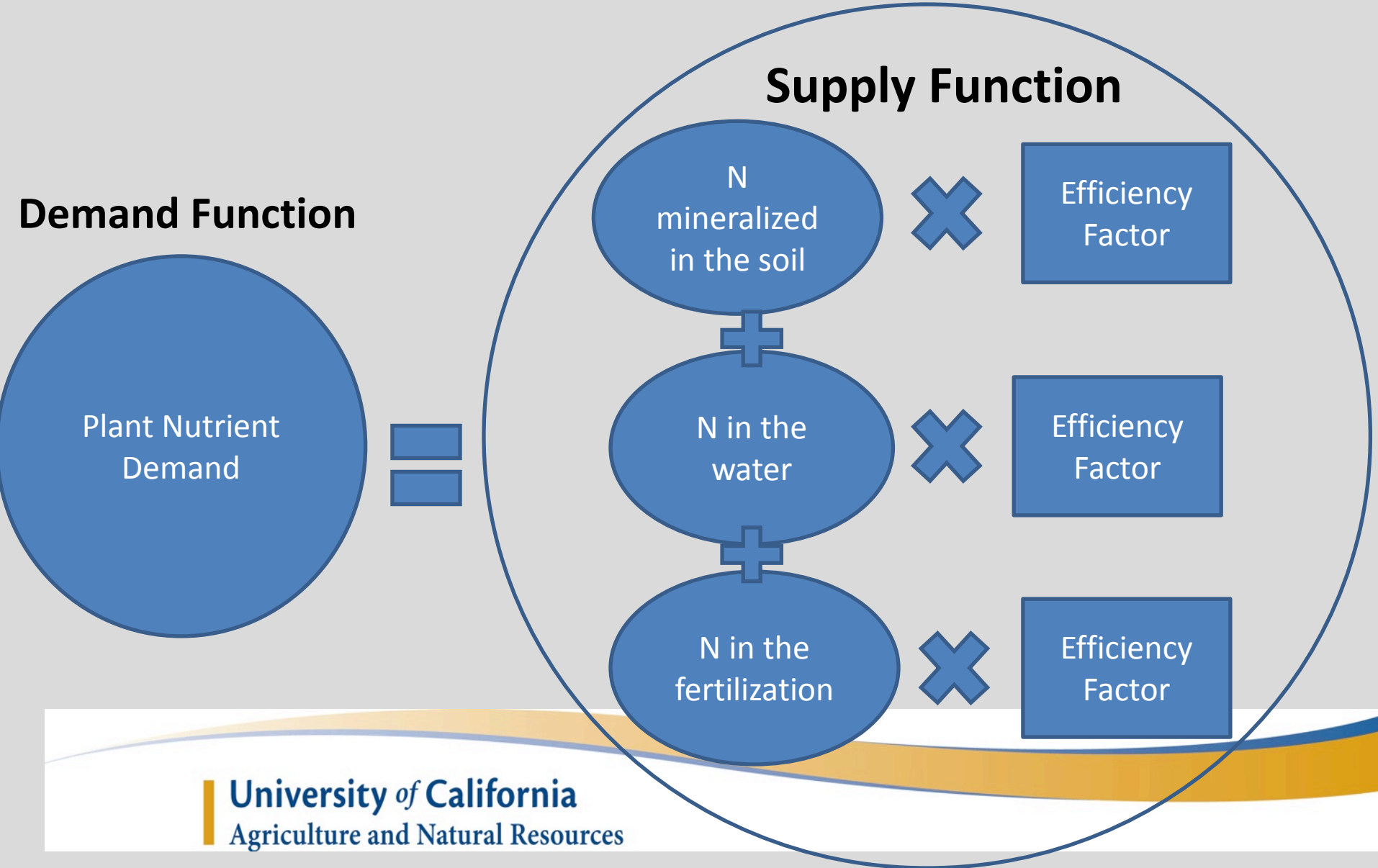
*The 4 R's are specific to every orchard each year.*

# How do you calculate the right rate?

- First, you need to know the tree nitrogen demand based on predicted yield. ✓
- Second, you need to calculate all the N credits. ✓
- Third, you calculate the amount of nitrogen still needed. ?
- Fourth, you incorporate the fertilization efficiency. ?

# The Right Rate Equation: "Avoid excess N, increase NUE, and increase profitability by accounting for all N inputs"

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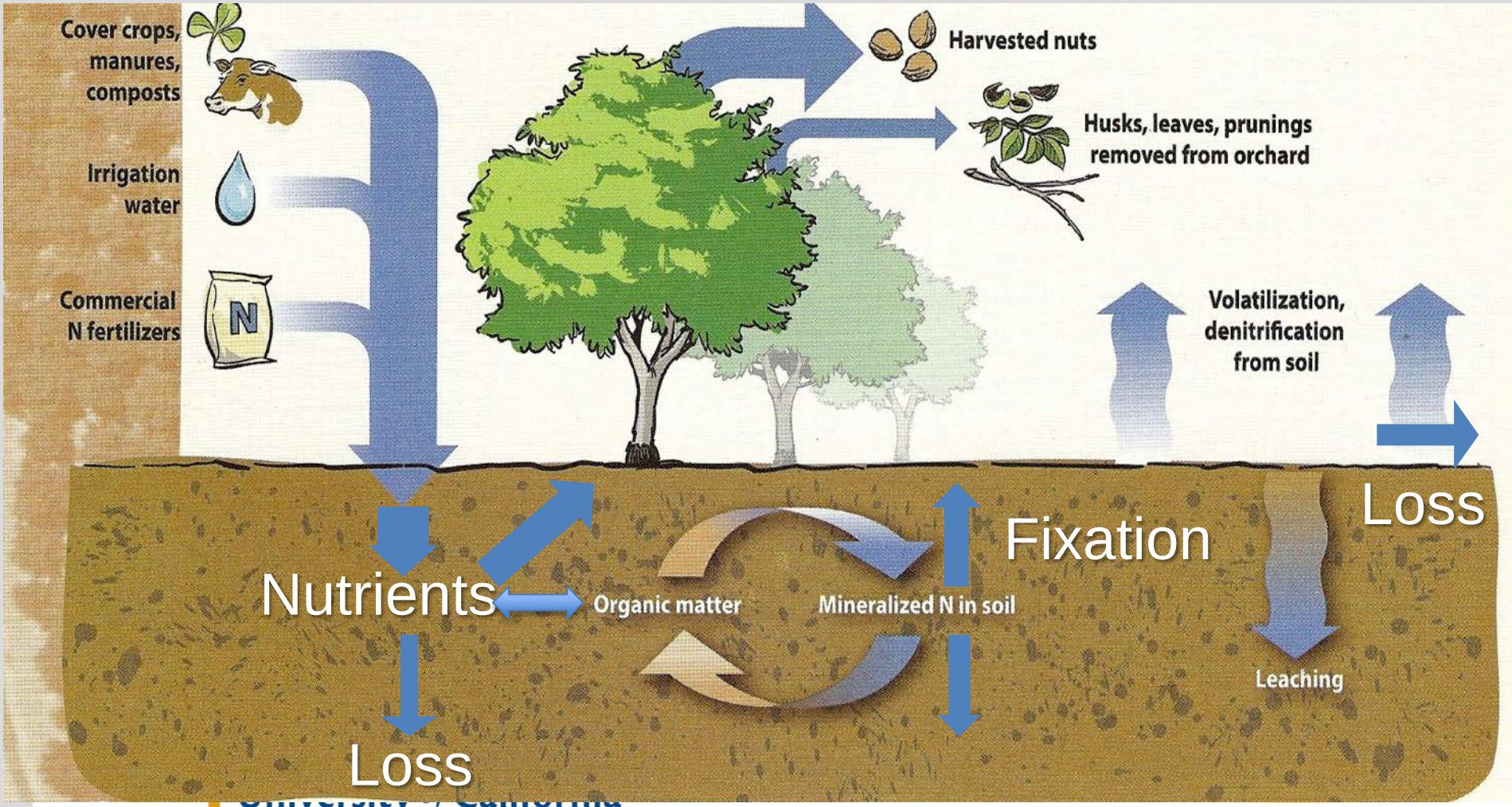
# Optimizing N Use in CA Tree Crops.

Supply (Rate) = Demand (Amount and Timing)

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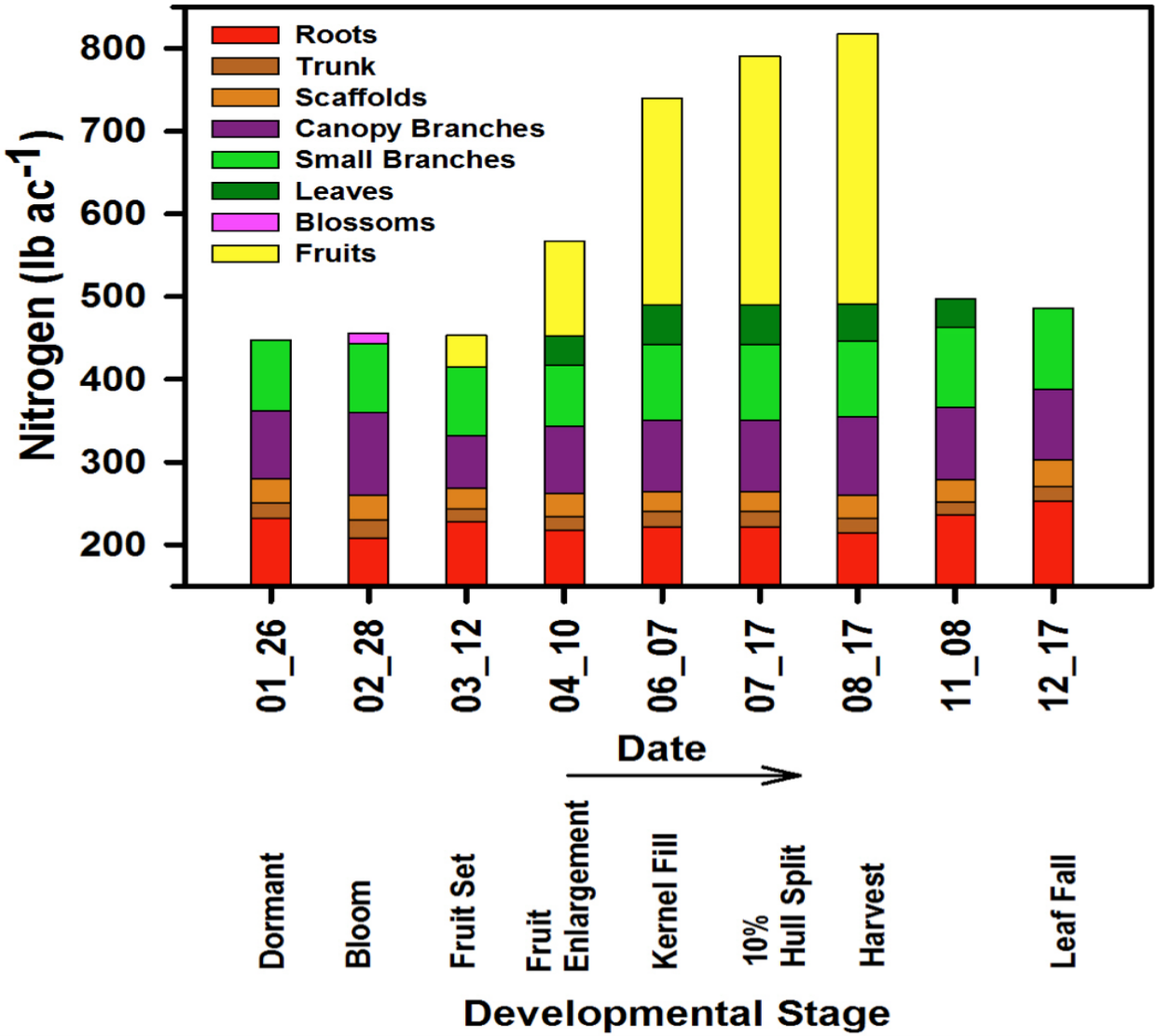
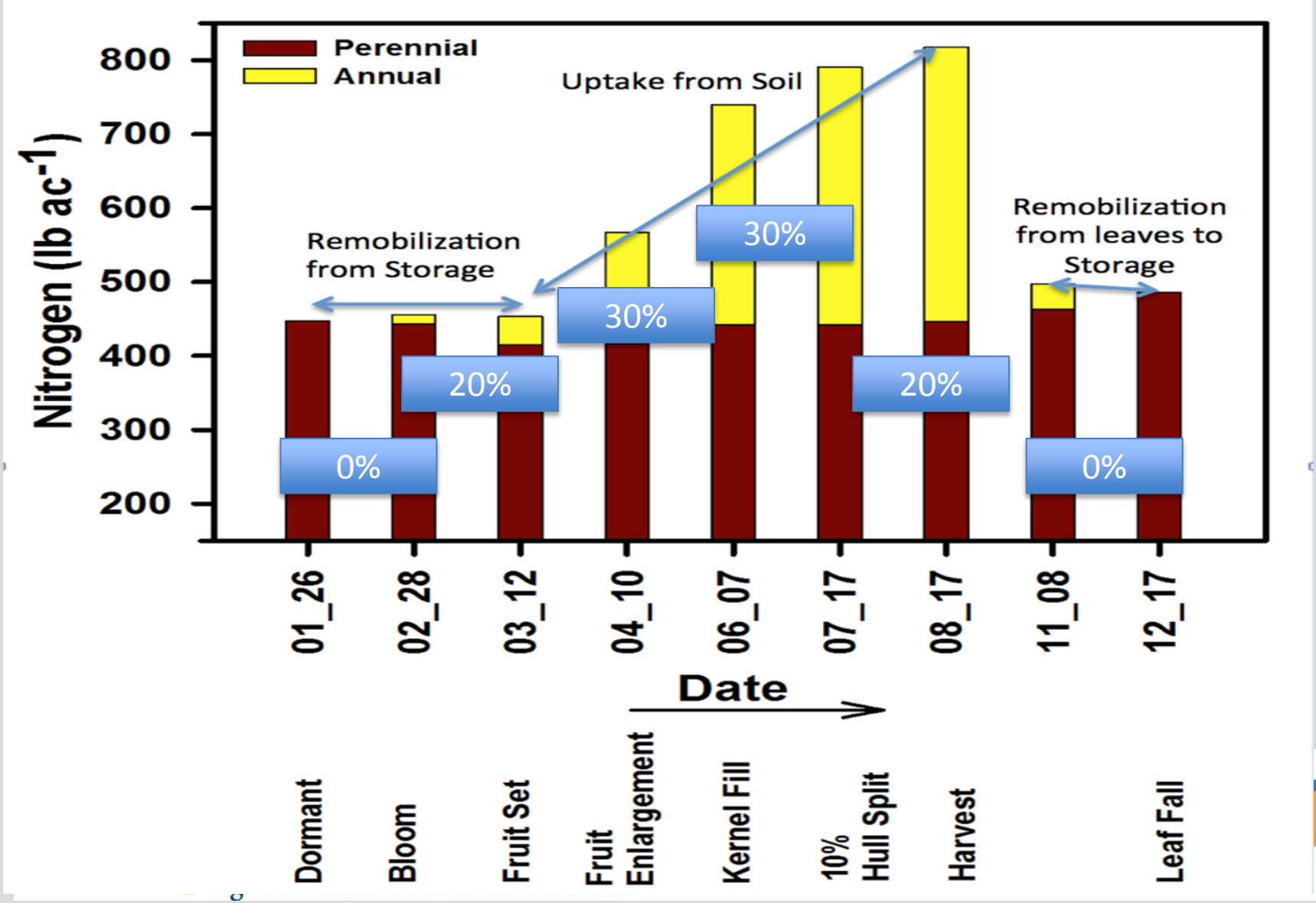
Kathy Kelley-Anderson et al: ANR Pub # 21623

# Almond Tree Nitrogen Demand



# Total and Annual Dynamics of N in Mature Almond Tree (data from 12 year old trees)



# UC Nitrogen Rate Study

Methods:

- Trees were 8-10 years old, excellent productivity
- Each treatment had 15 trees, 6 blocks
- Nitrogen was sourced using CAN-17, UAN-32
- N applied in 4 fertigations – 20%, 30%, 30%, and 20% for February/March, April, June, and October, resp.
- Leaf samples were pulled at multiple times
- Trees were harvested, individual tree yields determined
- 4 lb sub-samples collected from two data trees/plot
- kernel weights determined

# UC Nitrogen Rate Study: Yield Effect

| | | UAN 32 | | | | CAN 17 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Irrigation | 125 lbs | 200 lbs | 275 lbs | 350 lbs | 125 lbs | 200 lbs | 275 lbs | 350 lbs |
| 2009 | Drip | 2689 b | 2977 b | 3327 ab | 3507 a | 2512 b | 2634 b | 3064 b | 3605 a |
| | Fanjet | 2776 b | 3111 ab | 3263 ab | 3380 a | 3143 | 3130 | 3248 | 3216 |
| 2010 | Drip | 2859 c | 3426 bc | 3909 ab | 4332 a | 2624 c | 3191 bc | 3967 ab | 3995 a |
| | Fanjet | 2872 b | 3581 a | 3810 a | 3776 a | 3030 b | 3410 ab | 3993 a | 3898 a |
| 2011 | Drip | 3811 c | 4272 b | 4643 a | 4735 a | 3640 c | 4336 b | 4864 a | 4852 a |
| | Fanjet | 3870 b | 4014 b | 4480 a | 4425 a | 3803 c | 4159 b | 4452 a | 4398 a |

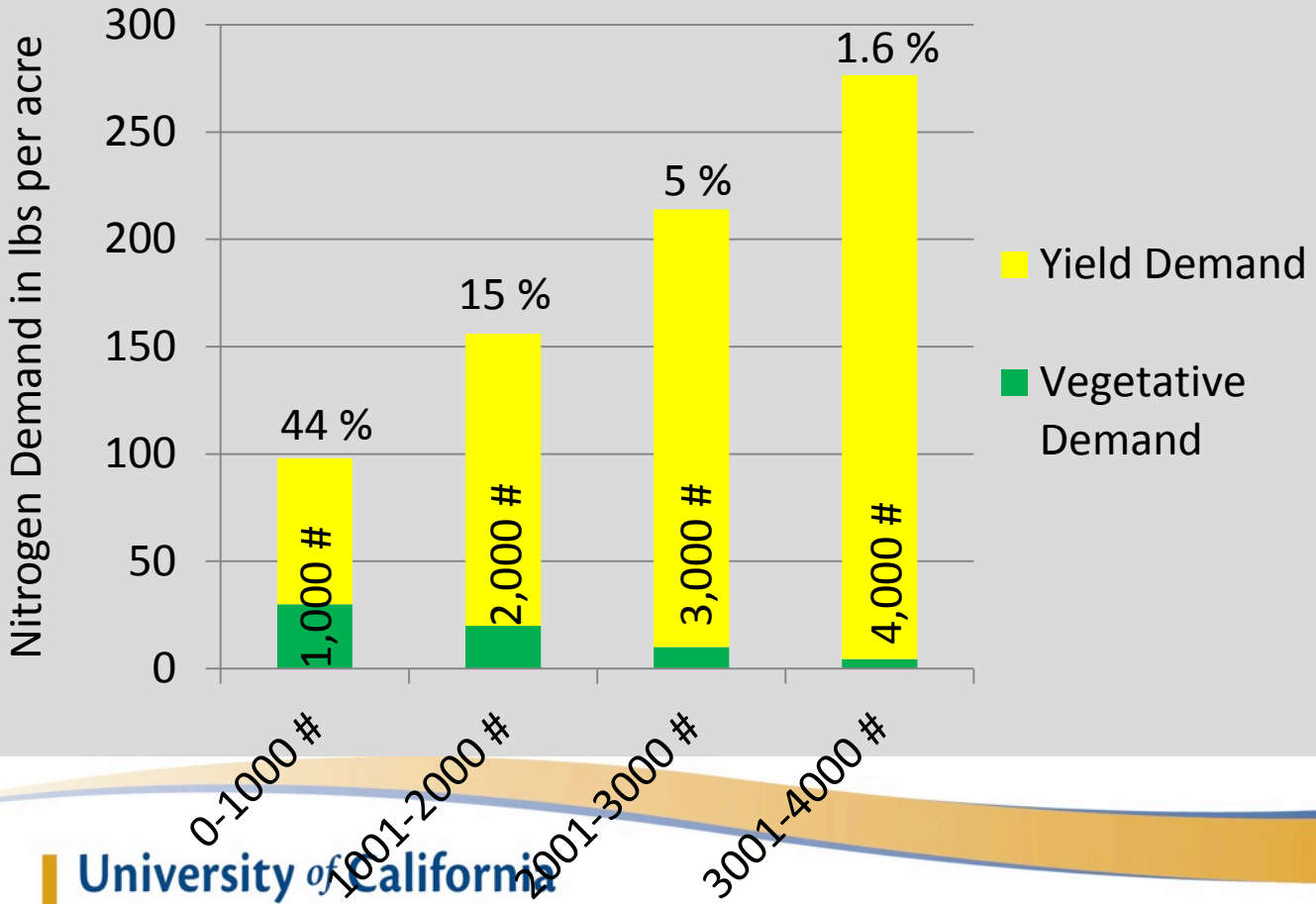
**Conclusions:**

Maximal yields reached with 275 lb, no gain from 350 lb treatment;

No difference between nitrogen source

No difference between irrigation system

# The proportion of annual N budget that goes to vegetation declines as the yield increases <u>above of 2,000 lb .</u>

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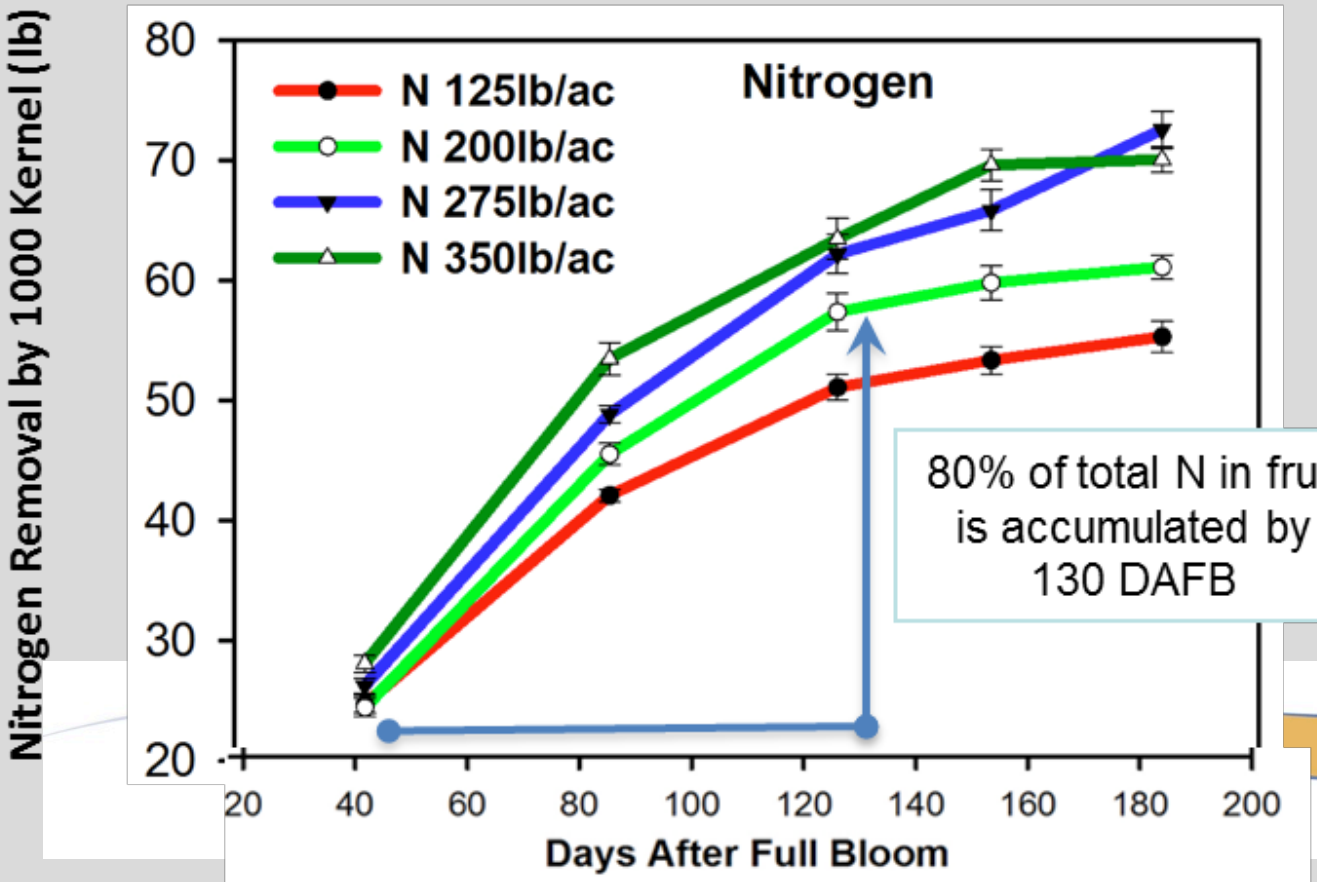
➔Applying more N than needed does not result in greater N uptake by fruit but does increase the potential for leaching loss.

➔There is less vegetative growth when yield is high even when N is applied in excess.




- Increasing N from 275 to 350 lbs N did not increase N removal by fruit.
- In plants receiving adequate N, 68 lbs of N is removed in 1000 lbs kernel yield.
- 80% of crop N is accumulated by 130 DAFB

# Right Rate: Nitrogen Demand in Almonds

**Nutrient removal Per 1000 lb Kernels**

Nonpareil

- N removal 68 lb per 1000

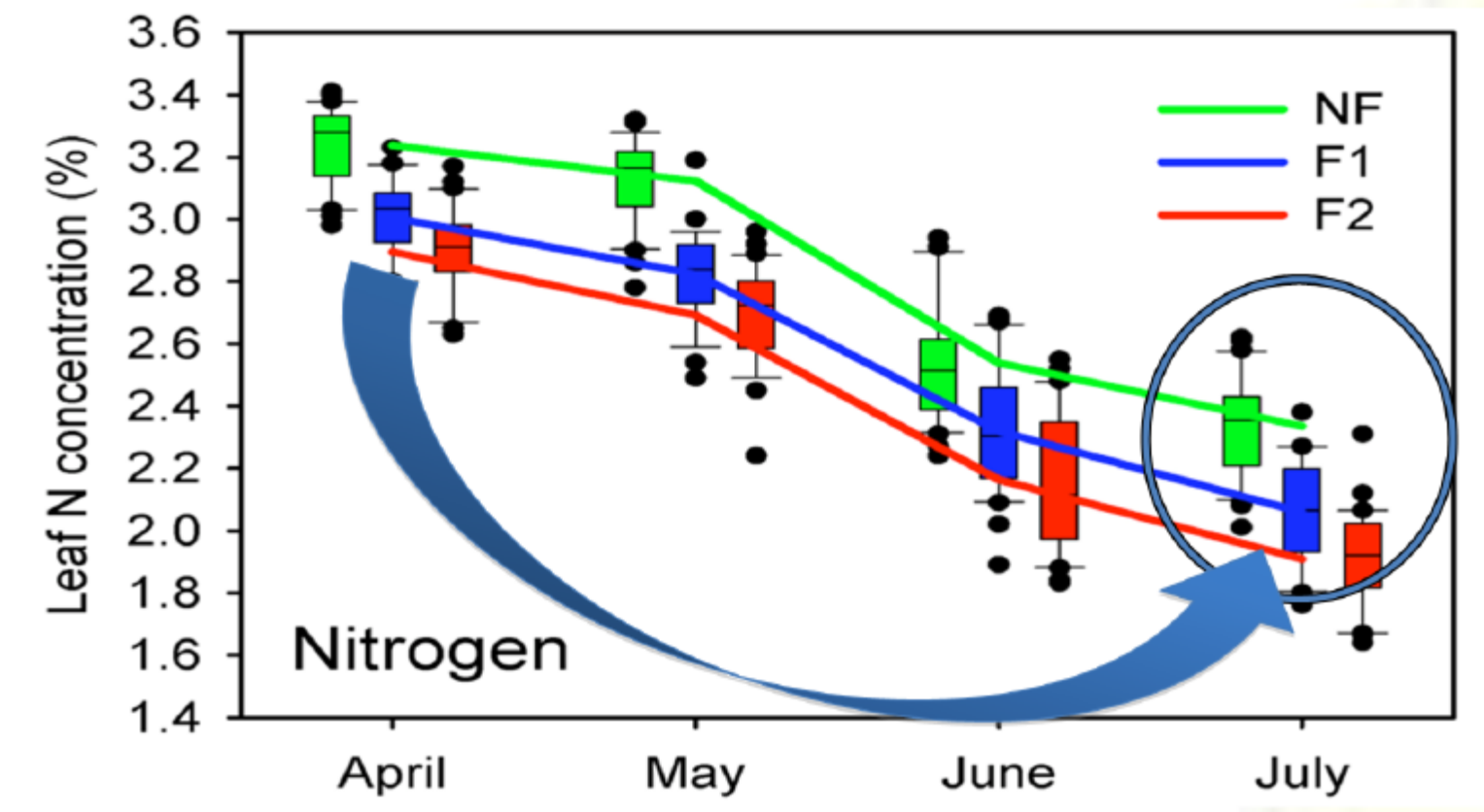
Monterey

- N removal 65 lb per 1000

Growth Requirement

- Yield 2,000 to 4,000 = 0 lb N
- Yield 1,000 to 2,000 = 20 lb N
- Yield <1,000 = 30 lb N

# UC Davis Nitrogen Rate Study: Leaf Sampling



# UC Davis Nitrogen Rate Study: Leaf Sampling

- Protocol:
  - Sample leaves from a single cultivar 43 days after bloom (+/- 6 days)
  - Collect leaves from 18-28 trees per orchard, combine leaves from area of concern
    - Each tree must be 30 yards apart
  - Collect leaves from 8 exposed spurs per tree between 5-7 feet off the ground for a total of 100-200 leaves
  - Send samples to the lab and request a full nutrient analysis. Data needs to be entered into model for correct June prediction.

# Right Rate: Almonds

- **Extension Article:** "Almond Early-Season Sampling and In-Season Nitrogen Application Maximizes Productivity, Minimizes Losses" by *Sebastian Saa Silva, Saiful Muhammad, Blake Sanden, Emilio Laca, Patrick Brown* **(Google it)!**
- Includes Practical Examples

3) If April tissue analysis predicts that your July tissue concentrations will be less than adequate, and if estimated yields ($Y_{est}$) differ substantially from preliminary predicted yields ($Y_{pred}$) as determined in (A) above, then **reduce or increase** N fertilization in subsequent fertilizations accordingly:
   a. Divide field estimated yields ($Y_{est}$) by preliminary predicted yields ($Y_{pred}$) = **Z**.
   b. Fruit Growth Application and Kernel Fill Application = (1.7 x Z) x Early-Spring Application Rate
   c. Fruit Maturity and Early Post-Harvest Applications = (1.2 x Z) x Early-Spring Application Rate. Note: In regions where significant rainfall may occur during this period, growers should consider use of a foliar application of N or supply N in a manner that minimizes loss potential.

# Almond Nitrogen Timing

- Should be soil dependent
  - Sandier soils should wait until leaf out
  - Clay, Silt, Loam soils may apply earlier
- 80% should be delivered before hull-split, 20% in the post harvest
  - Majority should be prior to kernel fill
- Example program: 20% March, 30% April, 30% May, 20% August/September

# Nitrogen Sources:

- **Urea** –converted to ammonium in a few days; must be converted to nitrate, can volatilize, water soluble, stable (~46% N)
- **Ammonium ($NH_4^+$)** – Used by plants, positively charged, acidifying
  - In strongly acidic soils, conversion to nitrate may not occur for weeks
  - Ammonium Sulfate (Acidifying, source of sulfur)
- **Nitrate ($NO_3^-$)** – Plant available form of nitrogen, negatively charged, easily leached
  - Calcium Nitrate (source of Calcium, creates a basic reaction)
  - Potassium Nitrate
- Blends:
  - Urea Ammonium Nitrate (UN-32) – liquid blend
  - Calcium Ammonium Nitrate (CAN-17) – liquid blend

# Nitrogen Sources:

- **Groundwater-** sourced as nitrate, should be considered in budget,
- **Manures/Compost –** Percentage varies by source, age of compost, Food safety issues
  - Mineralizes most of N within first year (up to ~85%)
- **Fulvic/Humic Acids, Compost teas–** efficiencies relatively unknown, thought to be high

# Supply Function
# Nitrogen in the Water: Free source of N!

- Formula for Nitrate: Nitrate concentration (ppm) x inches irrigation applied x 0.052

- Formula for Nitrate-N: Nitrate-N concentration (ppm) x inches irrigation applied x 0.23

- Example: Lab reports 10 ppm Nitrate or 2.27 ppm Nitrate-N and you apply 48 inches of water

  Answer = 25lb
  Currently we estimate that only 70% of the N in the water will be available.

Answer = 17.5 lb (25 x 0.7 = 17.5)

# Why is there a difference between Nitrate-N and Nitrate?

- When the report is Nitrate, then the results are expressed as "$NO_3$".
- When the report is Nitrate-N, then the results are expressed as nitrogen "N".
- How much N is in a $NO_3$ ion?
  - Atomic Weight of N = 14
  - Atomic Weight of O = 16
  - 14+16*3 = 62.  14/62=0.22.
  - Therefore, only 22% of Nitrate is N.

# Example

- Suppose the following:
  - Almond Demand Function: 2,500 kernel produced
    - 2.5 X 68 = 170lbs of N
  - Sum of N credits from N in the water = 17 lbs of N

**Nutrient removal Per 1000 lb Kernels**

Nonpareil
- N removal 68 lb per 1000

Monterrey
- N removal 65 lb per 1000

Growth Requirement
- Yield 2,000 to 4,000 = 0 lb N
- Yield 1,000 to 2,000 = 20 lb N
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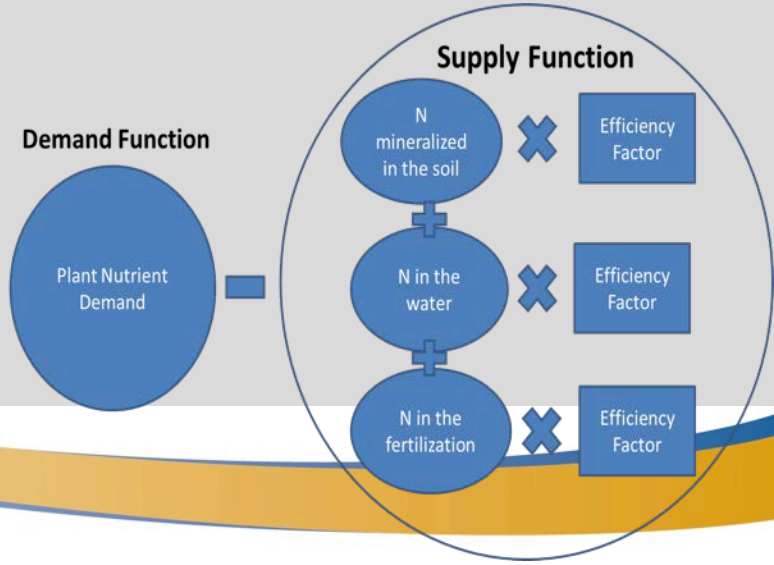

170 lbs N yield demand
– 17 lbs N supply from irrigation

= 153 N lbs needed by the crop

**Then, you incorporate the fertilizer efficiency.**

# Nitrogen Efficiency will likely be set at 70% by regulating agencies.

- This can be achieved is well managed orchards, though it is easier in some than others.

**153 N lbs /0.7 = 218 lbs fertilizer N should be applied.**

- However, if you do not manage N well this efficiency cannot be achieved:
- Efficiency can be reduced by:
  - Poor timing
  - Year to year yield variation (wrong rate)
  - Poor Irrigation uniformity (wrong place)
  - In field and between field variability (wrong rate, wrong place)

# Almond Tree Demand, When to Apply, How efficient.

**Tree Demand? = 68lbs of N for 1000lbs of kernel produced plus growth requirement (20-30 lbs) if yield is <2,000 lbs.**

**When to apply? = 80% during the first 4 months of growth, 20% post hull split – pre leaf senescence.**

**How efficient can we be if we do everything well? = 70% NUE**

# Bringing it All Together:

- Determining Total Crop Demand in lbs N
  - Expected yield divided by 1000 and multiplied by 62
- Subtract nitrogen applied through water
- Leaf Tissue Based Adjustment
  - If April N concentrations exceed 3.5%, it is likely that June fertilization can be omitted
- Determining N application rate
  - Subtract N applied through water from crop demand, multiply by 1.4 (assumes 70% efficiency factor)
- Timing of application should vary by soil type.
  - More “feeds,” the better

Nitrogen Prediction Models for Almond and Pistachio – Fruit and Nut Research & Information Center

fruitsandnuts.ucdavis.edu/Weather_Services/Nitrogen_Prediction_Models_for_Almond_and_Pistachio/

Researcher ID | TFF | Web of Kno...ience Home | UC Davis Library VPN | Plant Sciences Email | JPNSS | Patrick Brown | SmartSite | Apple | MyTravel @ UC Davis | Google Maps | Weather

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## Nitrogen Prediction Models for Almond and Pistachio

Google

These models are based on research conducted through **Advanced Sensing and Management Technologies**, a 4-year, multi-state project with goals to optimize resource use in deciduous tree crops. For project details, including investigative team, methodology and support, see project link.

**Nitrogen Management Tools for Almond**

1) Guidelines for Early Season Sampling and In-Season Nitrogen Budgeting (pdf)

2) Estimate almond tree demand: Almond Model for Calculating Nitrogen Demand

3) Interpret early season almond leaf samples:

Download these spreadsheets: *N-Prediction Model for Almond* (22K) and *N-Predition Model for Almond: large datasets* (317K) from this page: Crop Nutient Status & Demand in Almond

(Advanced Sensing & Mgmt Technologies website)

**N & K Prediction Model for Pistachio**

1) Guidelines for Pistachio Early-Season Sampling and In-Season Nitrogen Application Maximizes Productivity, Minimizes Loss (pdf). By *Muhammad Ismail Siddiqui and Patrick Brown*

2) Estimate pistachio tree demand: Pistachio Model for Calculating Nitrogen Demand

3) Interpret early season pistachio leaf samples: Pistachio Prediction Model (PPM)

# New Online and Tablet N Management Program

N Management Calculator available at the Almond Board Growers Website

Free and Anonymous (requires email address)

Or: Can be used as part of Californian Almond Sustainability Program (CASP)

# Nitrogen Rate Study: Hull Rot

*Rhizopus stolonifer* - or- *Monilinia fructicola*

Brent Holtz, UCCE San Joaquin

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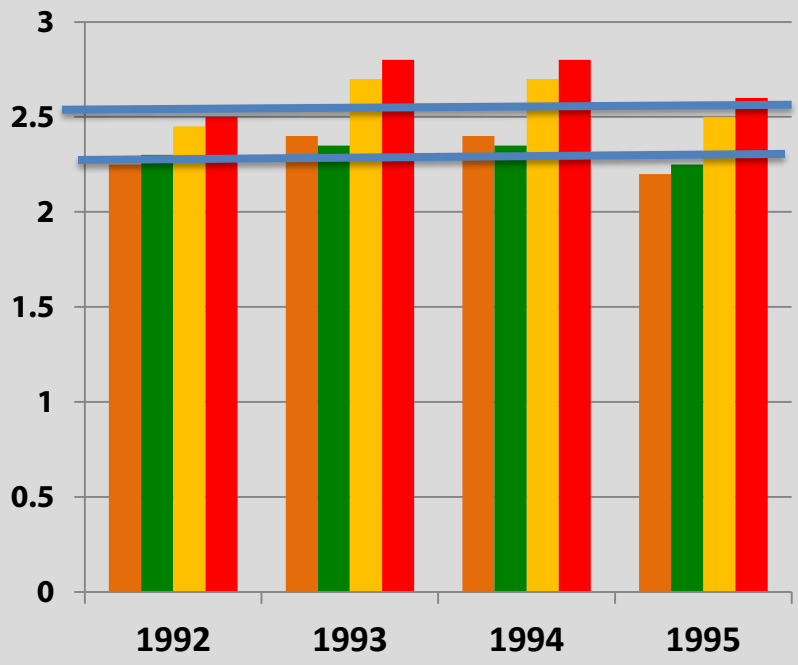
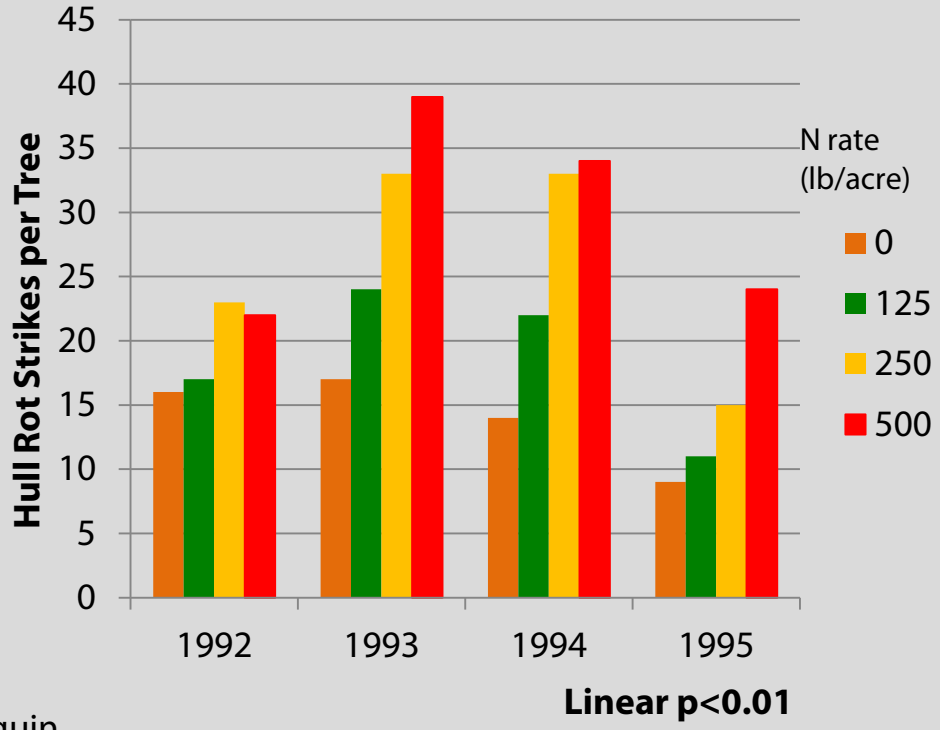
# Nitrogen Rate Study: Hull Rot

## Effect of Nitrogen Application on Hull Rot Incidence




Brent Holtz, UCCE San Joaquin

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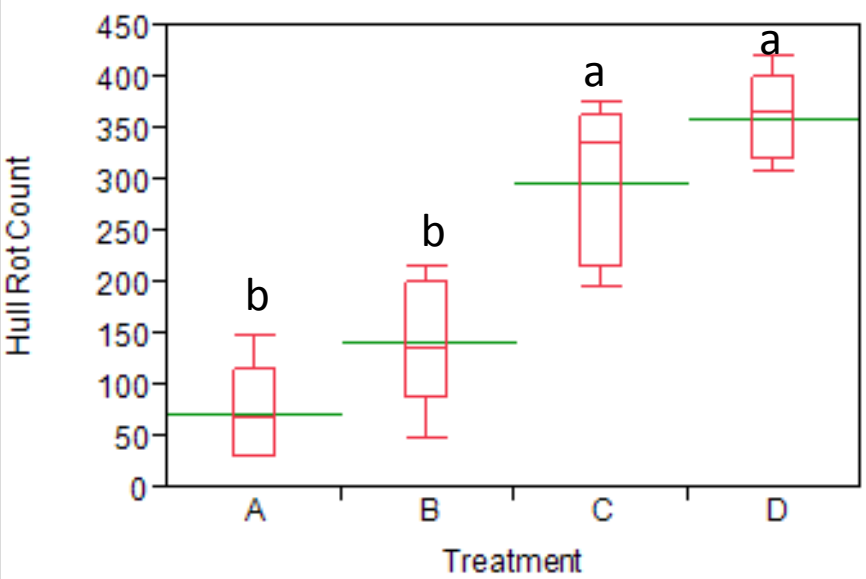
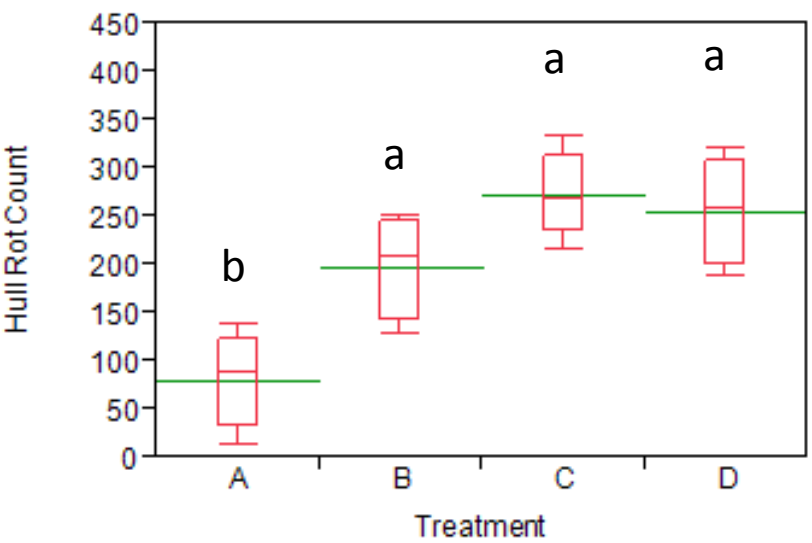
# Nitrogen Rate Study: Hull Rot

DRIP




Fan Jet




Treatments
A= N 125lb/ac
B= N 200lb/ac
C= N 275lb/ac
D= N 350lb/ac

Green line represents mean

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# Nitrogen Rates Study: Hull Rot

- N increases split timing by promoting vigor, thus increasing hull rot.
- Increasing hull rot as leaf N concentration exceeds 2.5% in mid-July
- N can be applied through July if:
  - supply do not surpass demand;
  - no new lush growth.
- Rate appears more important than timing.

# Developing Almond Orchards

- Nitrogen needs look to be around 25-30 pounds  for growth
- Needs to be added to crop requirements
- Be careful with the rate

# Questions?

- Thanks to:
  - Sebastian Saa, Saiful Muhammad, Blake Sanden, and Patrick Brown, UC Davis/UCCE
  - David Doll, UCCE
  - Paramount Farming Company, The Almond Board of CA, USDA, CDFA
  - Brent Holtz, UCCE